Information Flows in Nature Areas

Information Needs and Data supply for Location-based Services in Nature Areas

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This paper addresses the issues of analysing and developing added value geo-enabled content for use in Mobile Information Systems in Nature Areas. The research was carried out under the framework of WebPark, an EC-IST R&D project that developed a location aware application for nature/protected Areas. The research started with an evaluation of the existing services in terms of what information is currently available and its spatial relevance. This led to the observation that the tourism information analysed did not have an active geographic component and the geographic research data (e.g. animal counts/observations) had a clear mismatched as regards the visitors' information needs. Therefore, different types of data processing (including importing, remodelling, aggregating, reformatting, generalising and reclassifying) were performed and new methodologies in handling and presenting nature information had to be developed.

KEYWORDS

Nature information, Location-based Services, geodatabases, data processing.

INTRODUCTION

Recent years have witnessed a change from the passive, low key use of Natural/Rural areas for recreation to an explosion of tourism as a highly active and dominant agent of change and control in the countryside and associated rural communities [6]. Mobile Information Services (MIS) can play a role in helping visitors achieve full awareness of the richness of natural and cultural resources, improving awareness levels and contributing to eco-friendly visits. It must be underlined that protected areas are created above all with the aim of conserving natural heritage and secondly for supporting the leisure or tourism industry. In this regard, environmental education is, for a majority of the protected areas, a major mandate [8]. Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action [13].

This paper addresses the use of Information and Communication Technology, in particular of mobile location-aware information systems, to facilitate information access, exchange and provision in natural areas, in particular as concerns the processing of the information available in order to create added value, geo-enabled content. Developments in recent years have showed that mobile technology is becoming increasingly available and its usage is nowadays-widespread [2]. Therefore, mobile Internet devices with geo-location capabilities may create the opportunity of meeting the present information needs of visitors to natural areas. But although the technology is mature enough to deploy mobile and context aware applications (availability of high quality handheld computers and GPS receivers), most of the data available at the sites is not ready to be used in such applications. This paper elaborates on the process of the data management for WebPark. The first section describes the developed application. The second section specifies the evaluation and analysis of the information needs of visitors to recreational and protected areas. The third elaborates the data handling process. The process was subdivided into seven steps or stages: 1) analysis of the source data, 2) extraction, 3) transformation, 4) Loading, 5) Storage, 6) accessing and 7) display. The forth section introduces the mapping requirements and results. The conclusions from the exercise are described in the fifth and final section.

THE SYSTEM

WebPark is a research and development project funded by the European Commission that developed a series of services for users of protected areas. The service is based on wireless technology and is available for mobile phones and PDA's. Several personalized Location-based Services were developed within the WebPark framework. To date, the platform has been implemented at two partner sites: The Wadden Sea Islands, Netherlands and the Swiss National Park, Switzerland. For these two areas, a specific prototype has been developed and tested with real visitors (see Figure 1 and Figure 2).

The features of the system include:

- Automatic locating of a visitor on a digital topographic map (position obtained from GPS, via Bluetooth wireless connection to the PDA).
- Search for points of interest (POI) as hotels, restaurants, bike rentals, etc (around the position, ahead of, or in all the park);
- Access species information (fauna and flora): description and multimedia data;
- Intelligent retrieval of information according to a visitor's spatial behaviour, personal preferences and topographic and ecological considerations related to their location.
- Dynamic mapping of retrieved information.
- Ability to log comments indexed by location (e.g. an animal sighting, parking place). These comments can be public (shared on-line with other visitors).
- Ability to receive location-sensitive warnings with the proximity to interesting landscape features with facts and multimedia about these features.

Figure 1 – User accessing information about her surroundings.

Figure 2 – WebPark mapping user interface.

Three important issues that the service architecture was able to cope with were:

1. Since the user is mobile, the communication with the services is wireless;
2. Since the user is mobile and pedestrian, the devices used are palm-sized, thus the services

can rely only on limited resources and computing power from the user terminal;

3. Natural Areas usually have only partial coverage for wireless communication. WebPark services, however, need to be accessible all the time and therefore without reliance on the presence of a continuous connection.

INFORMATION NEEDS

This section specifies the evaluation and analysis of the information needs of visitors to recreational and protected areas. The goal was to understand the current visitor information flows, structure and possible deficiencies during the field visit. With this understanding it was possible to determine the data requirements for the Mobile Information System. This exercise was divided into three steps:

1. assessment of the needs of visitors while visiting the park - investigated through participant observation[1];
2. assessment of existing information services - evaluated through an extensive exploration of the actual information services available to the visitors, and
3. analyses of the visitors' information behaviour - assessed through a qualitative, survey-based investigation.

It started with the assessment of the visitors' information needs in the field. Subsequently, the current information availability was analysed. By comparing the "needs" with the existing "information services", it was possible to identify the information gaps. The next step was to identify the preferences of the visitors in terms of information access. These preferences, in combination with the information gaps, influenced the definition of the system and data requirements.

The method of participant observation was applied to assess the needs of visitors - in this paper we illustrate the results for the Swiss National Park [1]. Participant Observation is a popular and widely used research method in Anthropology and Ethnography studies, but is also applied in other scientific fields as consumer behaviour and marketing [12] or software engineering [10]. Participant observation is defined as the involvement of the analyst in the activities of the people in the context he is studying, where the observer should "immerse" himself as deeply as possible [11]. In the WebPark case, the participant observation was implemented through "shadowing". A researcher followed/ accompanied the visitors while they visit the park in an attempt to detect and record the visitors' problems and questions. The questions were categorized into topics (e.g. fauna & flora, landscape & navigation, park regulations, history) and classified according to their spatial sensitivity (information that is intrinsically geographically or not). The questions with a spatial reference were predominant, 64% of a total of 203 recorded questions (in several observation sessions). Questions without spatial reference accounted for just 36% of the total questions, but were often triggered by a spatial position (e.g. "Have the marmots started hibernation?" which has a temporal reference but no spatial, was triggered by being in an area of Marmot lairs). Most of the 130 questions with a spatial reference concern the topic navigation/landscape (41), flora (30), fauna (26), and geology/geomorphology (19). Most of the questions without spatial reference (from a total of 73), concern the topic fauna (24) or flora (20). Only a few questions apply to historical themes and research or the park in general [1].

The next step was to evaluate the *existing information services* in recreation/protected areas in terms of what information is currently available and its spatial relevance. This study was carried out

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[1] *Research performed by Abderhalden and Krug (2003)* [1] *within the framework of the WebPark project.*

for the case of the Swiss National Park (adapted from [7]). It included an extensive information analysis of tourist guides, web site and CD-ROM. The analysis was performed using a "reverse" approach. Although the information (the answers) were analysed, the intention was to identify questions that could be answered by the current available materials and that were comparable with the questions identified in the actual needs assessment phase. The information was classified into pre-established categories: "Nature"; "Park info"; "Recreational activities" and "visitor logistics". Categories and sub categories were established depending on the information found. The spatial sensitivity of the information was classified according to four classes and correspond to different levels of accuracy in position determination technology [3]:

- Spatially independent;
- Low (accuracy > 1 km) that can be obtain by means of Cell ID;
- Medium (30 m < accuracy < 1 km) can be obtain by means of Network-enhanced Cell ID or E-OTD;
- High (accuracy < 30 meters), can be obtain by means of GPS technology.

The Temporal Sensitivity of the information was classified according to five classes:

- Static or time insensitive (e.g. where and why was the park founded?);
- Low sensitivity or update rate <1 time/year (e.g. What are the main ongoing research projects in the park?);
- Medium sensitivity or update rate < 4 times/year;
- High sensitivity or update rate < 1 time/month;
- Real Time or updated at least every day (e.g. which trails are open today?).

Seventy-four "blocks" of information/questions were identified. Figure 3 shows the distribution of the questions between categories and subcategories. If a majority of questions are allocated to a certain category, the more extensive is the information available regarding that specific category.

The actual needs of visitors in the field were also classified by means of a similar process, which allows comparison between the information demand and supply. The results of the available information (Figure 3) were as follows: 45% of the questions are classified into "Nature"; "Recreational activities" were covered by 21% of the questions; the category "Park info" contained 18% of the questions, and "Visitor logistics" accounted for 16% of the questions. The distribution of the questions in relation to the different temporal sensitivity and spatial sensitivity parameters is illustrated in Figure 4. It is easy to see that the largest set of questions is time and space independent.

The comparison of the information demand (based on questions asked during the shadowed field park visit) and the information supply (based on questions that can be answered by available materials, such as CD-Rom, Leaflets, etc.) does not present major gaps. For the actual needs of the visitors, the majority of the questions were related to "nature" (fauna + flora + geology). This is also the topic from the existing information services that contains the most information resources. In contrast, the temporal and spatial characteristics of the information available (Figure 4) are discordant with the temporal and spatial characteristics of the information demand. Most of the questions from the visitors comprised a high spatial component, while most of the questions identified in the materials did not have, or had a very limited, spatial component.

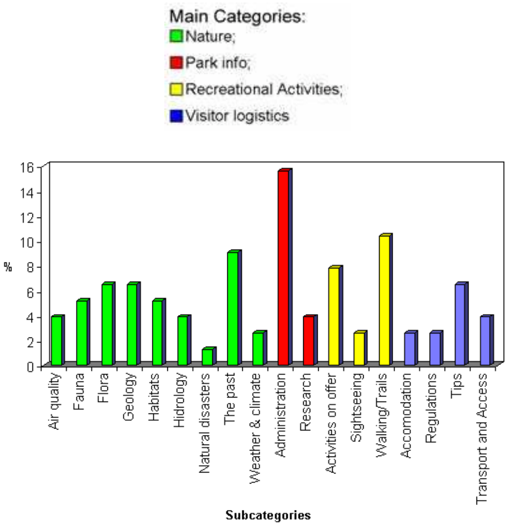


Figure 3 - Percentage of questions per subcategory and category (colours).

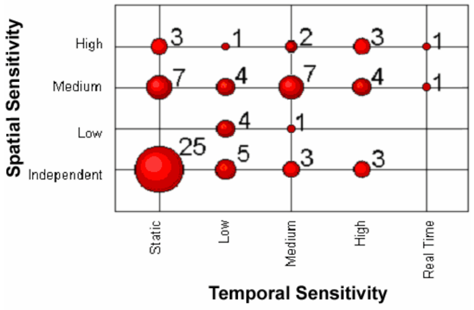


Figure 4 - Temporal and spatial Sensitivity of the information on offer [7].

In order to satisfy the visitors' information needs in the field, the system must, therefore, have available an extensive and diverse collection of "Nature" information. It should enhance the existing information on offer by assigning geographic relevance to the current information blocks. Furthermore, the information that is intrinsically not geographic (e.g. information about the behaviour of animals) should be associated with geographical locations where the need for such information will arise (e.g. the animal habitats or places from where visitors can see the animals).

The information needs of visitors in recreational and protected areas were assessed with the help of a survey. This exercise was meant to identify which services visitors are most likely to use. The most important services identified were "Maps and other information for orientation purposes based on the actual position" and "Safety information such as severe weather warnings, shelter harbours" (see Figure 5).

Based on these results, the data requirements for the system were defined.

N = 77	Important	Nice to Have	Less important	Not necessary
i) Maps and other information for orientation purposes based on your actual position	38.0%	33.8%	14.1%	14.1%
ii) Information on tidal flats, mud-walking possibilities	33.8%	41.6%	10.4%	14.3%
iii) Information about vegetation and animals	16.7%	43.6%	24.4%	15.4%
iv) Local information about current research projects	7.0%	23.9%	39.4%	29.6%
v) Thematic maps, for example geological, tidal maps	16.7%	41.7%	18.1%	23.6%
vi) Safety information such as severe weather warnings, shelter harbours	62.5%	26.4%	2.8%	8.3%

Figure 5 - Importance of information services (results from the Wadden Sea case).

DATA MANAGEMENT

The WebPark system and related processes can be simplistically viewed as a publishing tool that allows intense information sharing of local knowledge with the visitors. In order to provide true added-value for the visitors, the information available plays a crucial role. Geographic information and multimedia content needs to be adapted or created in order to meet the accuracy required and expectations from the visitor.

The GI content needed for the WebPark service could be divided into the 'background' and 'foreground' types. Typical background GI consists of topographic base map data e.g. roads, paths, coastlines, water features and boundaries; false colour imagery classified by land cover; terrain information and public service and safety information. By contrast, foreground GI contains processed and interpreted GI and multimedia such as animal distribution, POIs location, flowers in blossom and up-to-date photographs and other multimedia information.

In order to prepare the GI content for WebPark, an extension to the ETL (Extract Transform Load) [15] process was defined. Figure 6 illustrates the extended ETL process.

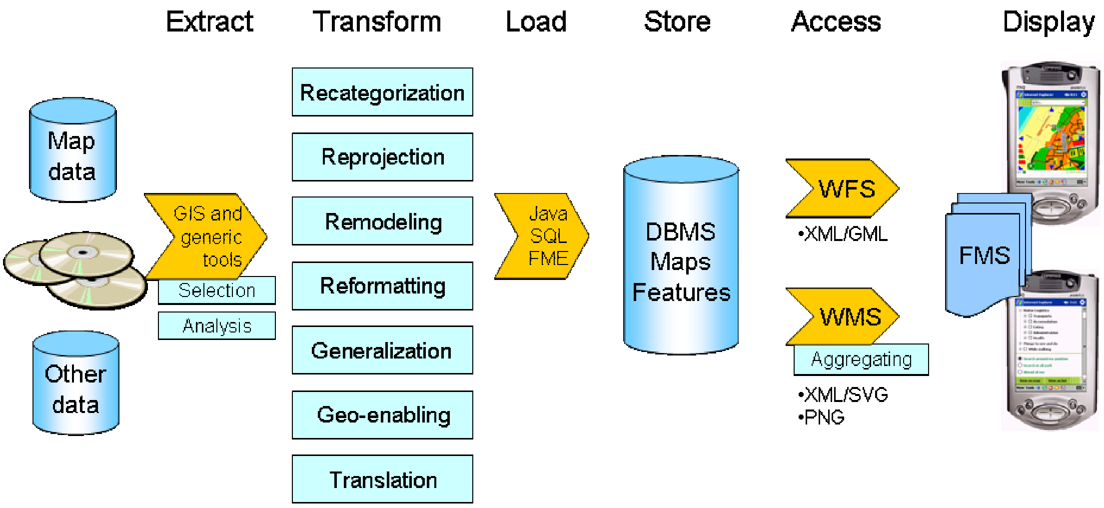


Figure 6 –Data handling flow in WebPark.

The process can be considered a linear process that starts in the determination of available datasets (information audit) and ends in the display of the information to visitors. It can be considered an ETL process, as the data is extracted from its original storage mean, transformed in order to cope with the specified data model and loaded into a relational-database. The extraction step also involves the analysis of the data in order to select a relevant data subset (occasionally not all attributes from a dataset are relevant and the geo-extent of the data sets should also be limited to the interested area). The selected data is then transformed through a set of operations necessary to harmonize and standardize the data according to the WebPark data model. These operations may involve recategorization, reprojection, remodelling, reformatting, generalization, geo-enabling or translation, depending on the dataset:

- Recategorization – involves structuring features hierarchically by subcategorising them according to their essential/cognitive qualities. I.e. into one universal park semantic tree system.
- Reprojection – spatial data is projected into a single coordinate system.

- Generalisation – involves applying various geometric processes such as filtering linework and aggregating features that are too small or defined with semantics that are too detailed.
- Remodelling - the data model of the data source needed to be harmonised to the WebPark data model
- Reformatting – heterogeneous data formats (mime-types) for multimedia native content need to be converted into the formats understood by the WebPark components.
- Translation - WebPark information is served in English, French, German and Dutch.
- Geo-enabling – associating a geographically-sensitive footprint to data - described in section Geo-enabling data

The transformed data are loaded and stored in the database where it can be accessed via web services interfaces: Web Feature Server (WFS) and Web Mapping Server (WMS). The WMS allows retrieval of the background maps and also specific maps linked to foreground information but containing relatively static content, e.g. seasonal animal distributions. The WFS enables access to the features that are provided in the format to be used by the application (GML). The client application caches these data in a File Management System (FMS) and the data are used to build the styled presentation layer (e.g. on demand maps of the location of POIs HTML lists of the animals around the visitors position).

Performing this processing involves a series of data states and conversions; a set of data models and interfaces transforming between models, with each stage of this decomposition having particular data processing requirements. Figure 7 illustrates these concepts.

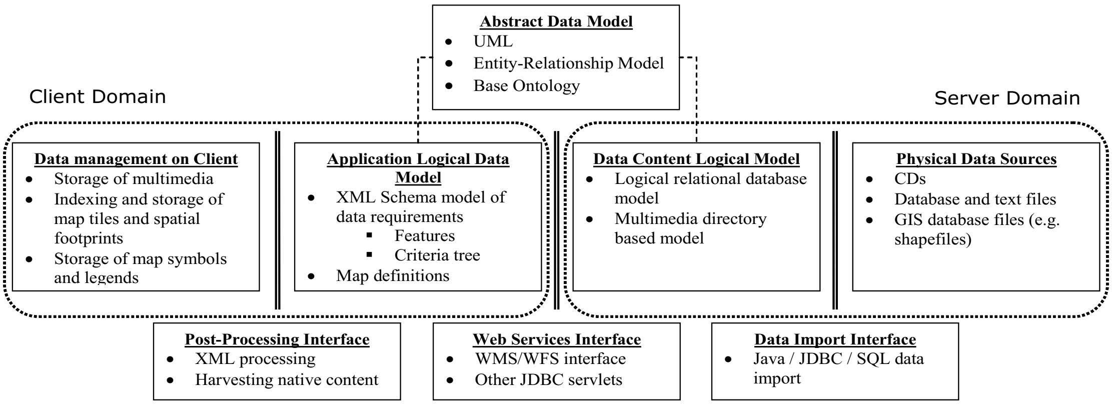


Figure 7 - WebPark data models and processing interfaces.

Figure 7 identifies four main data models and three interfaces. An abstract data model provides a single common specification of entities that is understood throughout the WebPark architecture despite being modelled logically and physically at different points. Figure 8 informally illustrates part of this model, the feature model.

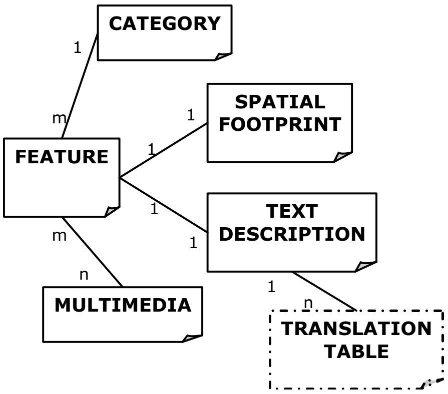


Figure 8 - Abstract Feature Model

The Source or “Physical Data Sources” stage represents the heterogeneous models of the base data, collected from the various sources determined during the information audit process. The **extraction**, **transformation** and **load** processes then convert these data models, across the “Data Import Interface”, **storing** them in a single object-relational database (DBMS) or file-system based content management system; the “Data Content Logical Model”. WebPark end-user applications have their own data models designed to match their internal logic and processing constraints of a client device. This is the “Application Logical Data Model”. Data **stored** in the database is transformed into this model across the “Web Services Interfaces”, (WFS and WMS) during the **access** process. WebPark services are defined to operate seamlessly when the user is either online or offline. This means that all the data related to the “Application Logical Data Model” should be batch **accessed** (harvested), cached and indexed on the device.

GEO-ENABLING DATA

One of the main conclusions of the initial information audit was that there was a clear mismatch between the information currently provided by the park and the visitor information needs. Most of the questions from the visitors had a high spatial component (e.g. “what animals can I see around me?”, “can I make a picnic here?”), while the information audit revealed that the available info did not have, or had a very limited, spatial component. The information audit also revealed that the GIS research data was not structured in an interesting way from the visitors’ perspective. A fundamental issue during the **transformation** process was therefore how to make these data suitable for use in a location-based service. One of the main issues for the spatial data gathered for research projects was that it lacked association with background information, such as descriptive text and multimedia information. Another was that the geometry models were often insensitive to the context and geography of a visitor’s location. For example, they did not consider the constraints imposed by topography, physical access and visibility. The issue with information that was specifically aimed at tourists was the lack of an associated with a, context sensitive, spatial footprint.

Remodelling scientific data for species

The method to organize the data made a separation between feature entities and their spatial occurrence (see Figure 8). Spatial occurrence was modelled with geographical units based on factors related to the foreground features, for example habitat suitability or actual observations, or on human factors related to the world as the user perceives it, for example the visible region around them or a section of the path they are on. This separation was made because:

- The amount and type of data available on spatial occurrence of species differed markedly between regions and species. Hence the system needed to support a wide range of different ways of describing the likely spatial occurrence of a species types (for example habitat suitability, observations, density/distribution models, expert knowledge, home ranges etc.)

- Depending on the service, human factors were often more important than ones purely based on inventory. For example, to provide information to support observing animals it was important to consider constraining factors such as where would actually be visible for a visitor taking into account the canopy cover, the topography and the proximity to a trail. This helped overcome the limitations of pure Euclidean radial based searching which would be ignorant of such obstructions.

- The applications needed to run on the device when it was offline using cached data. This meant that data storage on the device needed to be managed. Using geographical units that were distinct from the features they aggregated meant that data required to perform spatial searching could be reduced.

- It allowed the presentation of data with maps to be processed differently from the data required to index spatial queries. Map data could be optimized for cartographic considerations (for example using cartographic generalisation) and data to be used on the client optimized to support efficient searching, for example by using highly simplified spatial footprints.

Figure 9 illustrates the modelling of visibility regions in the mountainous terrain of the Swiss national park [5]. This involved computing the drainage morphology for stream channels at different Horton orders. The resulting hierarchy of regions gave an approximation of the area visible from a point at different scales. These regions were overlaid with forestry to take into account visual obstruction from vegetation.

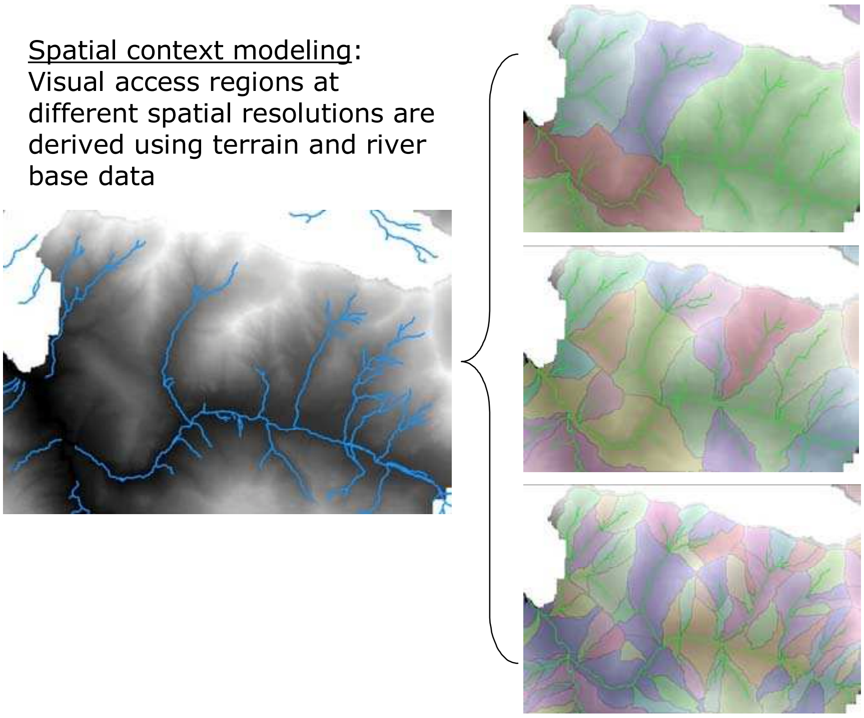
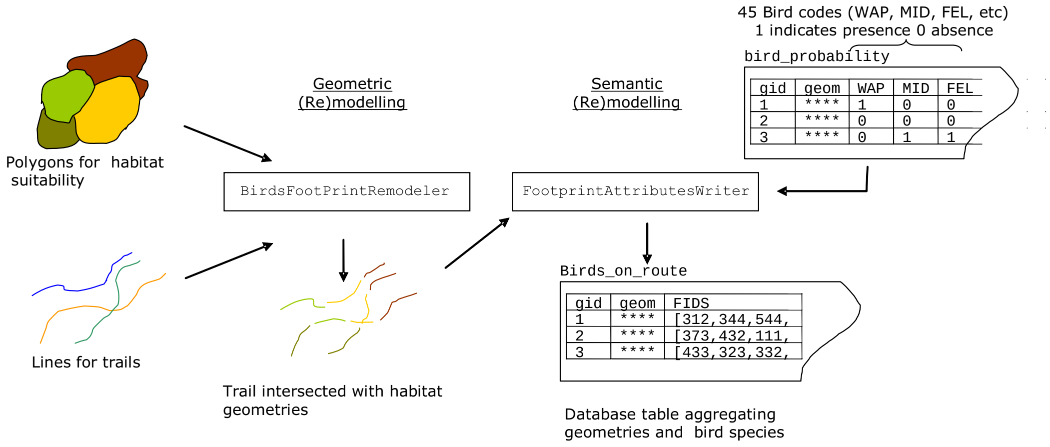


Figure 9 - Visibility regions

Figure 10 describes how information on the occurrence of different types of bird was remodelled by aggregating information from models of habitat preference in the Swiss national park [9] to sections of walking trail.



bird_probability

gid	geom	WAP	MID	FEL
1	****	1	0	0
2	****	0	0	0
3	****	0	1	1

Birds_on_route

gid	geom	FIDS
1	****	[312,344,544,
2	****	[373,432,111,
3	****	[433,323,332,

Figure 10 - (Re)modelling process for birds.

Geo-enabling multimedia

The National Park interactive CD-ROM proved to be a very rich resource. It contained over 800 high-quality photographs, detailed texts with numerous internal and external links, videos and sounds. Moreover, in 5 different languages: German, Romansch, French, Italian and English. Therefore, one of the requirements demanded by the park administration was to have the richness of the CD-Rom available to the visitors in the field during the hikes. The CD-Rom was previously only accessible through desktop PCs, therefore limiting the exploration of the information to largely indoor environments.

Although it was possible to extract the information in a feature format with all the multimedia pieces of information packaged into the data model (category, text descriptions, photos, links and translations), this data was not attached to specific a geographic space. As a result, it needed to be adapted: it was necessary to add a spatial component to the multimedia available. The geographical component allows that the vast amount of information from the CD-Rom to be filtered based on the visitor's location or sorted by proximity. I.e. it enabled the geographical management of the retrieved data by the visitors.

Based on expert knowledge, the hundreds of CD-Rom extracted features were divided into 3 groups, depending on its geographical effectiveness:

1) Non-geographic - information that is not linked to a specific location but that should still be available through the system (e.g. general rules of the park, history);

2) Geographic – information that is directly linked to a physical location (e.g. hotel, sightseeing spot). These data can be precisely portrayed by the mapping service. This information is defined as a point, line or polygon and specific portrayal rules were defined for map representation for each category (e.g. specific intuitive icons or colour polygons).

3) Semi-geographic – information that is not directly linked to a precise location, but that should be available in certain areas (e.g. background information about marmots). There are no GIS observations dataset for marmots in the park research database, and the precise location of where the visitors can see a marmot is not possible to determine, therefore the information on the marmots cannot be linked to a specific point or polygon in the map. Nevertheless, based on expert knowledge, there are areas where tourists should be aware (on the lookout) for the animals and the information on marmots should be available via the system (available as a response from the "what's around me" query in certain areas). However, these areas or location cannot be portrayed on the map since, most likely, the

visitors will not find a marmot at such location and it would be frustrating or at least misleading to represent an exact location for the animal. The geometries defined for these data are only to give geographic relevance to the information and the geometries are not to be visualized in the map. The places are not real physical locations, but rather Metaphysical locations where the visitor should have access to the information. These locations are typically defined by multipoints or multipolygons as the National Park experts indicate several locations where the tourists should be aware of the semi-geographic information.

MAPPING

The mapping requirements for WebPark took three forms:

- Background maps (Figure 11) - typically topographic maps that allowed the visitors to locate and orientate themselves and as navigation aids by associating topographic maps with the current GPS position of the visitor. Special cartographic rules were defined as the maps are meant for display in digital small screens and to be used in outdoor environments. For example, highly contrasting and intense colours were found to be more effective in bright daylight conditions in contrast to more traditional visualisation recommendations (Bertin 1983, Tufte 1991).

- Real-time dynamic maps (Figure 12) - Point-of-interest maps, in response to users' ad hoc query. Here feature data was used for both searching and indexing as well as portrayal.

- Static descriptive maps (Figure 13) - Overview maps, for example showing animal distributions were examples of the static descriptive maps. They showed broad patterns that aggregated information over longer time scales (for example, seasons). These maps could be pre-computed and cached. They were then associated with the features as a form of multimedia content.

Figure 11 - Sample of background maps (the all island of Texel is displayed).

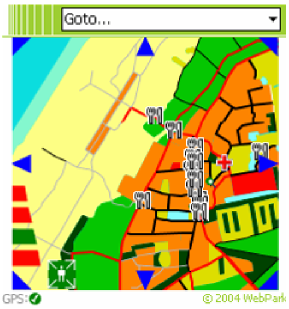


Figure 12 - Sample of real time dynamic map displaying the location of restaurants around the visitor

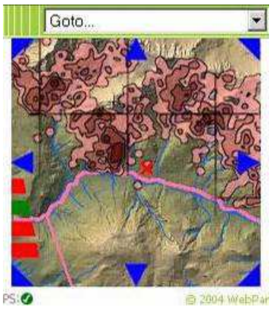


Figure 13 - Sample of static descriptive map (seasonal animal distribution).

Map Scales

The mapping service provides maps at four scales. The scales chosen are not exact relationships but are logical semantic scales. Due to the small screen of the device, the scales were defined in order for the screen to display logical geographical units, without the need to pan. The geographical units or semantic scales chosen were (ordered from the smallest to the largest scale):

- All Park (smallest scale) – displays the all park in the screen (no panning necessary). Useful for the visitors to locate themselves in the park (Figure 11).

- Route – intends to display the all route or hiking path in one screen. Naturally, routes differ in size and geometry and this scale is sometimes not effective for all routes. Nevertheless a compromise can be achieved.

- Habitat – intends to display the all habitats (vegetation polygons) where the visitor is.
- User (largest scale) – displays the user position and 50 meters around the user. Useful for the visitor to locate points of interest precisely mapped (e.g. a marmot hole, restaurant).

Temporal sensitivity

The analysis of information needs demonstrated the necessity to provide data at a range of spatial as well as temporal scales. The different maps can be categorized into groups, according to the temporal sensitivity of their geographic data. The maps can be divided into:

- Low sensitivity – geographic information that rarely changes (e.g. topographic background maps). Such maps are used for navigation and to contextualize foreground information. It's unlikely that these maps change for serveral years, thus they can be pre-cached in the device (reducing the need for wireless data traffic and data updates).
- Medium sensitivity – corresponds to geographic data that depends on the season and that may change every year or maximum two times a year. Typically derived from aggregated information, these maps are indicative of patterns rather then precise locations (e.g. thematic maps that represent animal distributions or surfaces showing the intensity of observations over time: landscape polygons are graded coloured depending on the number of animals sightings in that polygon on the previous year). Such maps give geographical knowledge to the visitors. They enable the visitors to be aware of which animals they may encounter. These maps can also be pre-cached in the device.
- Real time or updated every day – corresponds to dynamic geographical data with constant updates (e.g. animals' observations or safety conditions of a particular route/track updated by park rangers during their walks). The information is to be updated in the device everyday and several times a day, by making use of wireless connectivity when available. An interesting scenario that can be envisaged in the large game parks, for example in Southern Africa, where game spotting is the primary activity. Presently, visitors plan their daily trips based on maps available at the base camps where rangers and other visitors indicate with pins the latest animal sightings. The mapping service of the mobile information system can provide a 'virtual pin board', recording and mapping animal observations (via wireless internet when available) in real time. These maps are typically the navigation maps overlayed with point datasets coloured by time of observation.

CONCLUSIONS

The mobile information services can be built upon:

1. existing tourism information;
2. environmental sciences research data; and/or
3. tailored collected data.

Nevertheless, the analysis of information needs revealed a mismatch between the existing information and the visitors' needs for temporal-geo-information. To overcome these limitations the proposed methodology goes beyond the spatial definition of data into a geographical definition that takes into consideration environmental contexts and human factors and the temporal sensitivity issue was tackled with the aggregation of data series into comprehensive temporal map scales (e.g. seasonal species distributions). Geo-enabling enhanced the existing data with a geographical component that enables the vast amounts of information available to be filtered and sorted using the positioning of the visitors. These processes augmented the potential added-value of the existing data sets.

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